E82-10373
CR-169168

HCMM HYDROLOGICAL ANALYSIS IN UTAH

FIRST QUARTER REPORT

Data Handling

A significant portion of the time during the first quarter of this study has been spent in the aquisition and manipulation of HCMM data tapes which cover the Utah Lake area. All but four of the data sets originally ordered have been received and stored within our system. A total of 59 images are now being analyzed; 25 day visible, 25 day infrared, and 9 night infrared scenes. These span the period from 13 May 1978 to 14 November 1979.

Our intention has been to analyze the data on the BYU DEC-10 system. However, the HCMM tapes are recorded at 1600 bpi and the DEC-10 tape drives only operate at 800 bpi. Therefore, the BYU DEC-VAX system which has duel speed tape drives is used to read the tapes. A program was developed to extract from each file on the VAX the portion of the data which covers Utah Lake. This window is 84 columns wide and 120 rows long. The data for each window have been transferred and stored on the DEC-10 system.

Utah Lake is, of course, only a small area on each HCMM scene. Figure 1 shows the lake's location and shape. The lake is identified on the image by scaling the associated HCMM prints, using the row/column location on the prints, and calibrating the measurement to the number of rows and columns. While this method is somewhat crude, the lake has generally been located on the first trial.

Output Modes

Two modes of output are currently being utilized. Each lake file is output on the line printer in I3 format which yields a digital hard copy record of the

(E82-10373) HCMM HYDROLOGICAL ANALYSIS IN UTAH Quarterly Progress Report (Brigham Young Univ.) 17 p HC A02/MF A01 CSCL 08H
N82-32795
Unclas
G3/43 00373

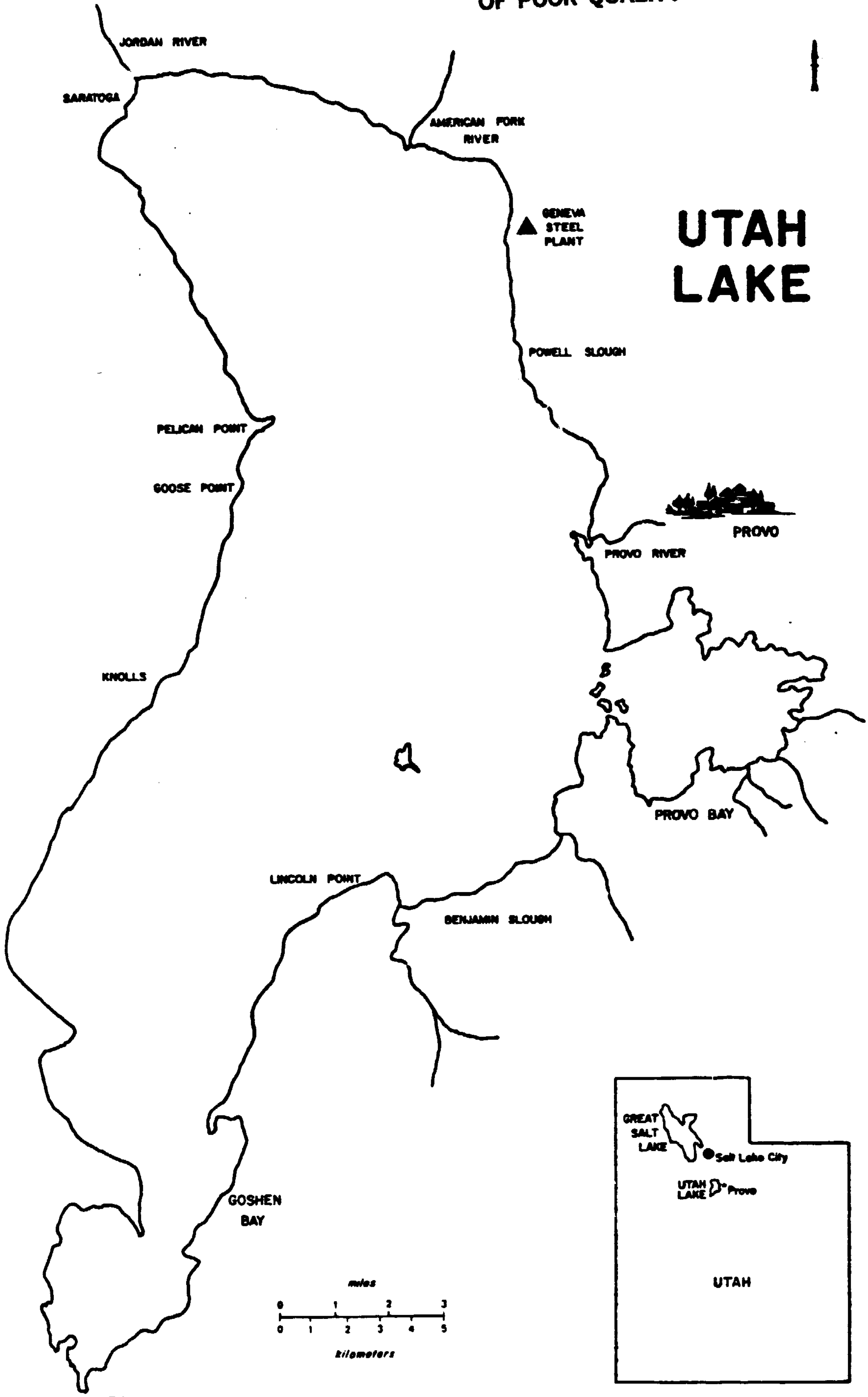

Figure 1. Location and Configuration of Utah Lake.

intensity value for each pixel. This mode has been very useful in correlating to lake measurements of temperature, algae concentration, and turbidity and to groundwater measurements.

A second output mode using color graphics is also being used. A program was developed to display the data on the Tektronics 4027 color terminal. The color code, window size and pixel scale can be altered to fit the needs of the analysis. Examples of these capabilities are shown in Figure 2.*

The sequence of color pictures given in Figure 2 is very interesting as it covers the life of an algae bloom on Utah Lake. The day infrared (DI) pictures are on the left and the day visible (DV) are on the right. From top to bottom the dates are; 4, 11 and 21 September, 1979.

The first indication of the bloom appears to be in the 4 September DV picture (2). Any value greater or less then the number range is displayed as black. The black spot is therefore an area of high reflectivity. It is occuring in a warm region of the lake, but there is no indication in the DI picture (1) of particularly high temperatures associated with this area. The 11 September pictures show that the algae bloom area, which has drifted northward, yields both high infrared and visible values. By 21 September, there is little trace of the previous growth. Data for 16 September, which has been ordered and is expected soon, will give addition information with respect to the demise of this bloom. Algae measurements taken on the lake for this time period are presently being studied in order to evaluate the correlations.

Picture 4 indicates that at maturity the algae reflectivity was as great as that of the surrounding valley vegetation to the east and greater than the mountain top to the west. The corresponding thermal image (picture 3) shows a

---

*Persons receiving reports without color prints may refer to those submitted to the technical administrators.

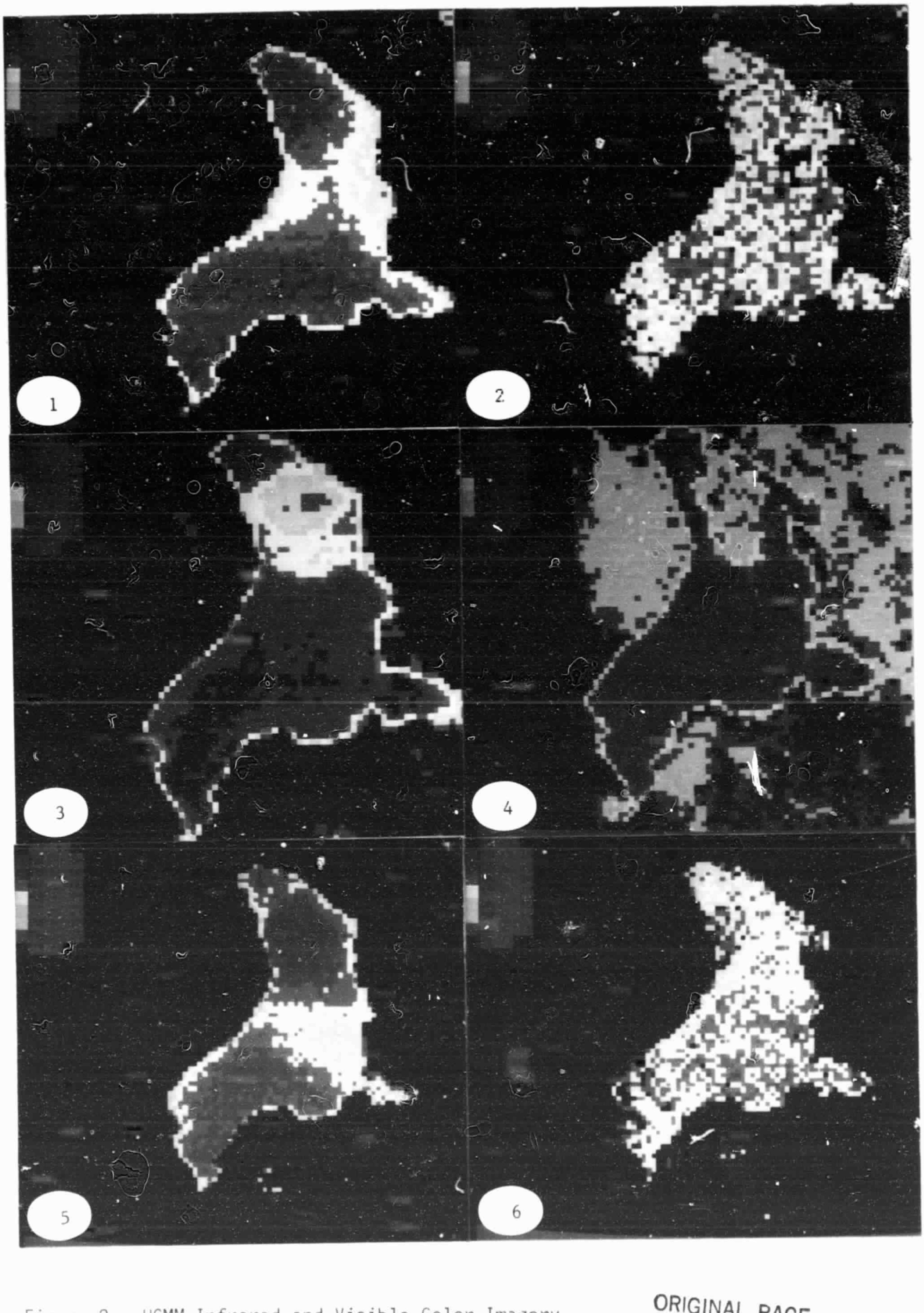

Figure 2. HCMM Infrared and Visible Color Imagery

ORIGINAL PAGE
COLOR PHOTOGRAPH

temperature difference across the lake of more than 24 intensity units which is approximately 8 °C.

Migration of the warmer areas within the lake shown in pictures 1, 3 and 5 are of particular interest in the study. Wind data is available for the 2 year investigation period and is currently being reduced for correlation analysis. It has been well established that wind over shallow Utah Lake creates waves which disturb the bottom sediments resulting in high turbidity. Higher reflectivity values from south to north on the lake's west side (pictures 2 and 6), which do not correspond to higher temperatures (pictures 1 & 5), would seem to indicate this sediment turbidity. Evaluation of the wind data may show that the prevailing westerlies are responsible for this higher reflectivity.

Temperature Calibration

As thermal data from the tapes were reduced and digital output produced, preliminary temperature calibrations have been made. The first major undertaking of the calibration was to locate township and range lines and plot them on transparent Utah Lake overlays. This is necessary in order to locate the surface sampling stations in relation to the HCMM pixels. The majority of the ground truth data locations are based on the township and range grid. Geometric triangulation using several prominent points around the lake, the USGS quadrangle maps, and scaling ratios produced satisfactory overlays. The significant difference between radiation intensity from water versus soil and vegetation make the lake boundaries relatively easy to locate with respect to the quadrangle maps. This is unlike some other HCMM investigations over small land surfaces.

Data for the temperature calibration have been obtained from two major sources; the Utah State Division of Wildlife Resources (Fish and Wildlife Service) and the U.S. Water and Power Resources Service, WPRS, (Bureau of Reclamation). WPRS data versus HCMM data are plotted in Figure 3. No WPRS measurements correspond to the same day as the HCMM overflights. The nearest

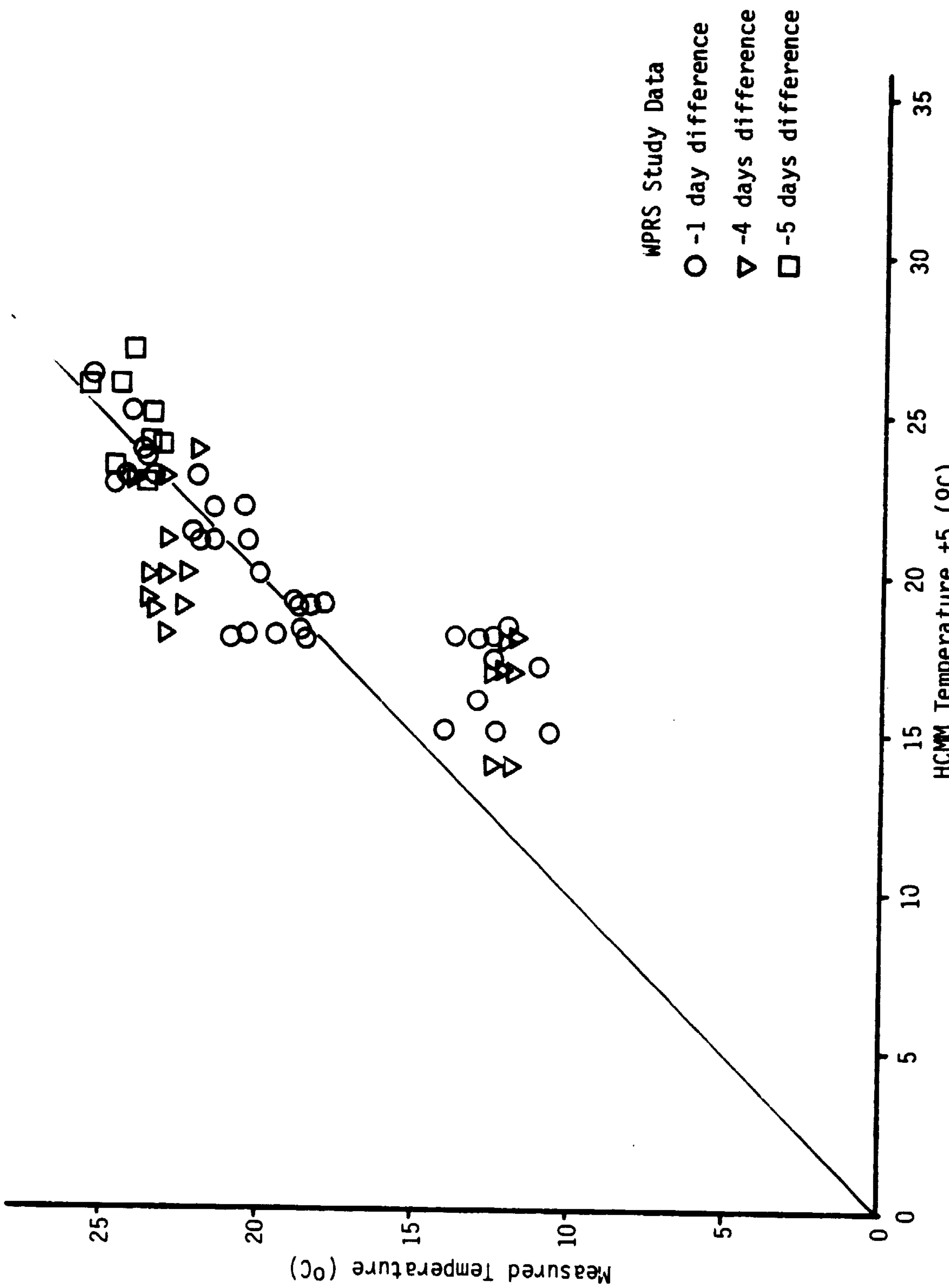

Figure 3. MEASURED VS. HCMM TEMPERATURES - MAG DATA

data have 1, 4, and 5 days differences. HCMM products received and being utilized in this study have had the -5.5 ^{o}C offset applied. In plotting Figure 3 this offset was effectively negated by adding 5 ^{o}C to all data. This is consistent with other HCMM investigators as discussed by Barnes & Price (1980).

The preliminary relationship displayed in Figure 3 indicates good correlation when the +5 ^{o}C is incorporated. This does not include all of the anticipated data. The lower temperature data which doesn't fit on the equivalence line is from 22-23 Sept. 1978 for the 1-day difference and from 9-13 May 1978 for the 4-day difference. This data would actually be equivalent if the 5 ^{o}C were not added. However, a physical explanation for this discrepancy is that there were significant air temperature warming trends (> 5 ^{o}C) over both periods. The HCMM temperatures were taken in both cases at the end of the periods and there would most likely be actual rises in surface water temperatures approaching 5 ^{o}C. Air temperatures were quite stable over the time periods involved in the other data in Figure 3. Solameter and hygrothermograph measurements are also currently being examined in order to determine the effects of climatological parameters on the HCMM/ground truth temperature relationships.

The Fish & Wildlife data plotted in Figure 4 are for the same day as the HCMM overfights. The correlation with the equivalence line is quite good. Some of these water temperature measurements were taken within one pixed width (500 m) of the shore. Where it was obvious that the corresponding pixel intensity included shoreline area, the value from the next pixel out was used. The few points in Figure 4 which are inappropriately high in measured temperature may be so because of shore or very shallow water influences within the pixel. Present work with this data includes examining 1,4, & 5 day differences in order to evaluate the reliability of the results presented in Figure 3.

ORIGINAL PAGE IS
OF POOR QUALITY

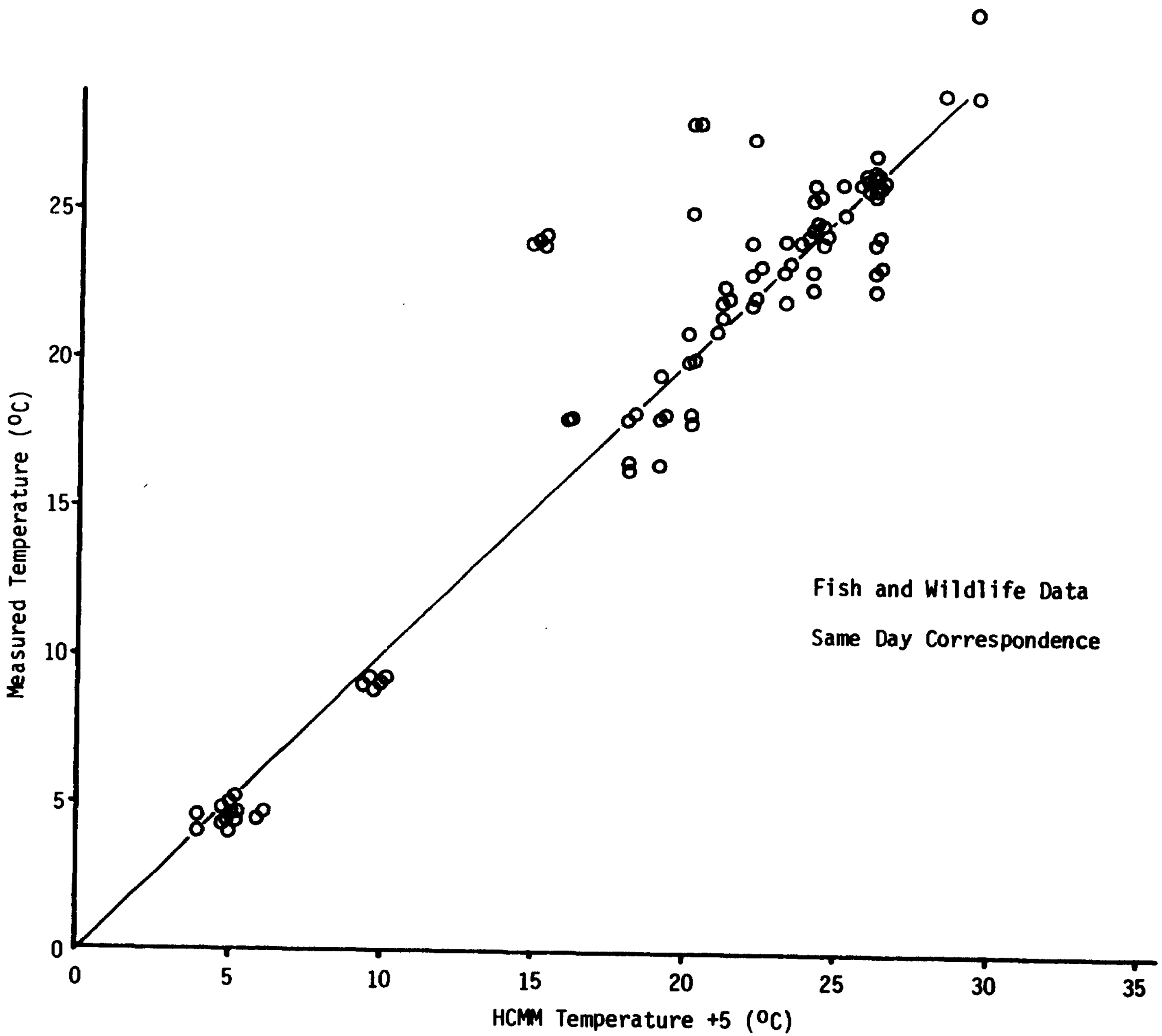

Figure 4. MEASURED VS. HCMM TEMPERATURES - FISH AND WILDLIFE DATA

Temperature and Algae

Preliminary analyses of non-diatom net plankton (algae), turbidity, nitrogen, phosphorus, and NCMM temperatures have been made and are shown in Figures 5 thru 9. These are for 2 time periods only; one in early August and the other in late August 1978. Many more data sets will eventually be included in these correlations. All HCMM temperatures are directly converted from the digital data and do not include the 5 °C addition.

Figure 5 shows the semilog relationship between the HCMM surface temperatures and the total algae concentrations at the same location. This data, along with that of several other days which have been evaluated but are not shown here, indicates that temperature increases with algae concentration. The lines are not statistically significant, but are just best-fit eye-approximations. The reasons for the difference in slopes between time periods are presently being examined. Also the relationship between HCMM temperature and various predominant algae species will be investigated. In all cases actual correlation coefficients and other significant statistical parameters will be determined.

The growth of the netplankton as a function of available nitrogen and phosphorus is being evaluated. Figures 6 and 7 show respectively the general relationships between algae concentrations and total nitrogen and total phosphorus concentrations. Our preliminary findings indicate a direct relationship with varying slopes for both nutrients. In late August the algae appear to require higher concentrations of both nitrogen and phosphorus. Study of temporal and spatial variations and of different species will be part of the continuing nutrient impact investigation.

Temperature and Turbidity

A small number of turbidity measurements are also available during August 1978 and are shown in Figure 8 plotted against algae. More data points are needed; however, there is some verification that turbidity increases with algae

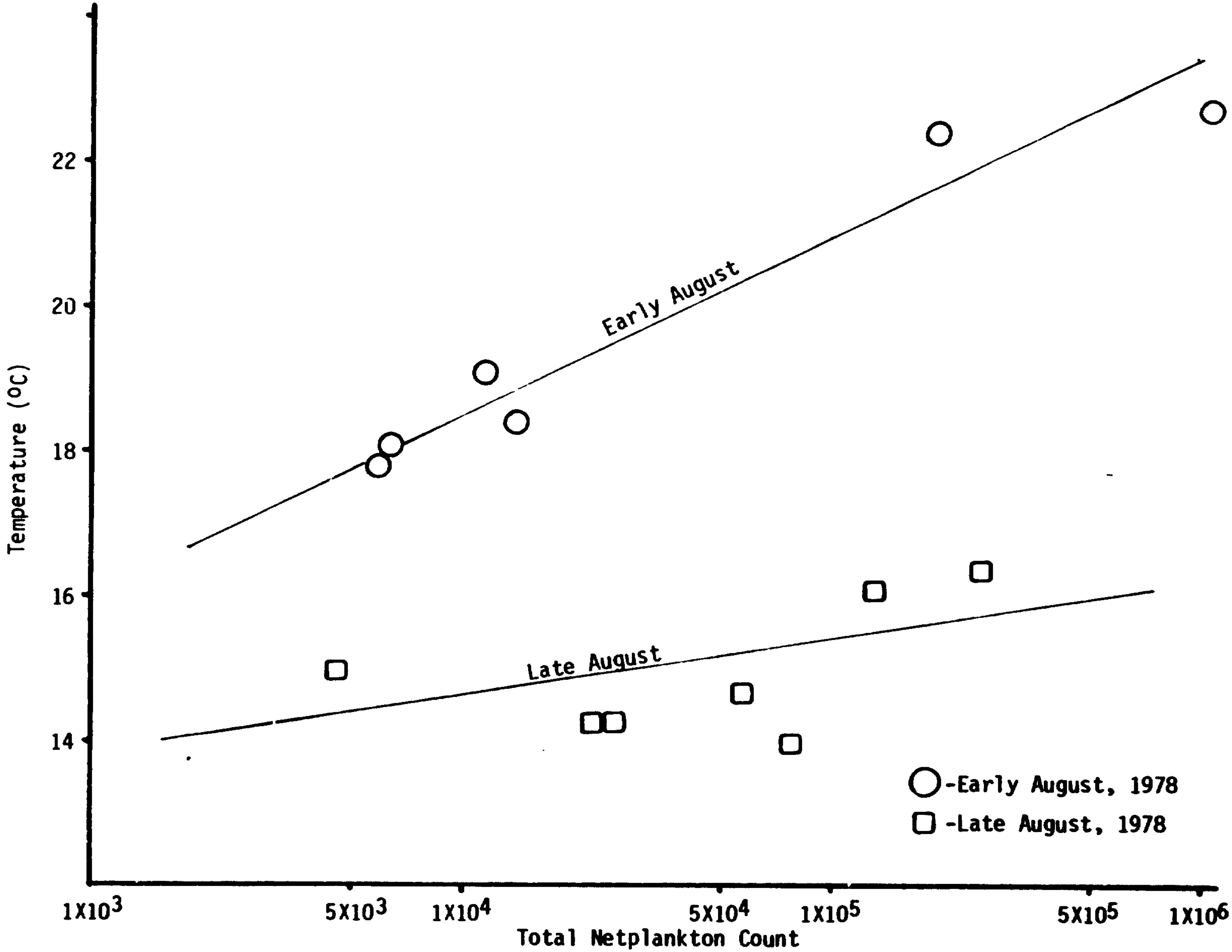

Figure 5. HCMM TEMPURATURE VS. NETPLANKTON

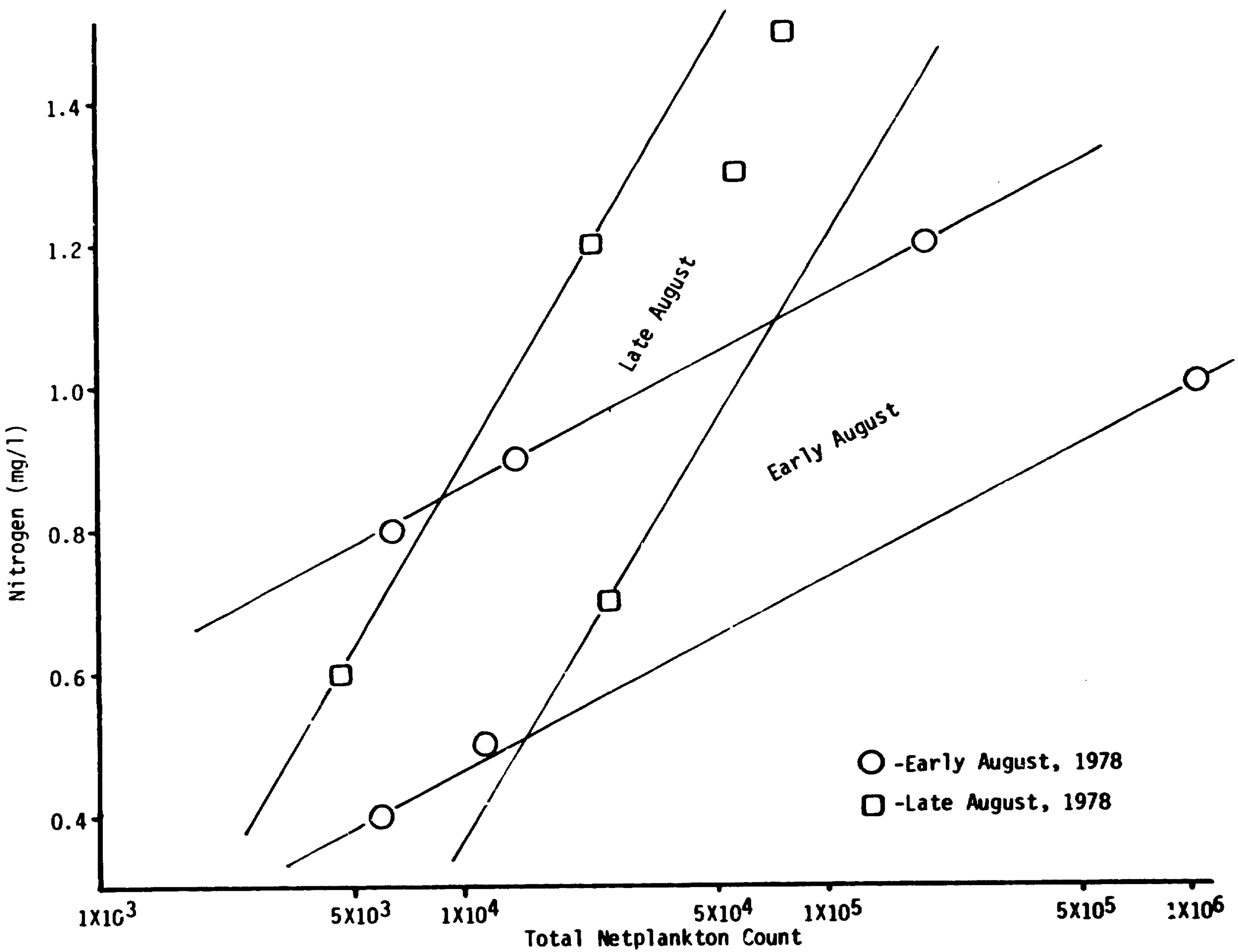

Figure 6. TOTAL NITROGEN VS. NETPLANKTON

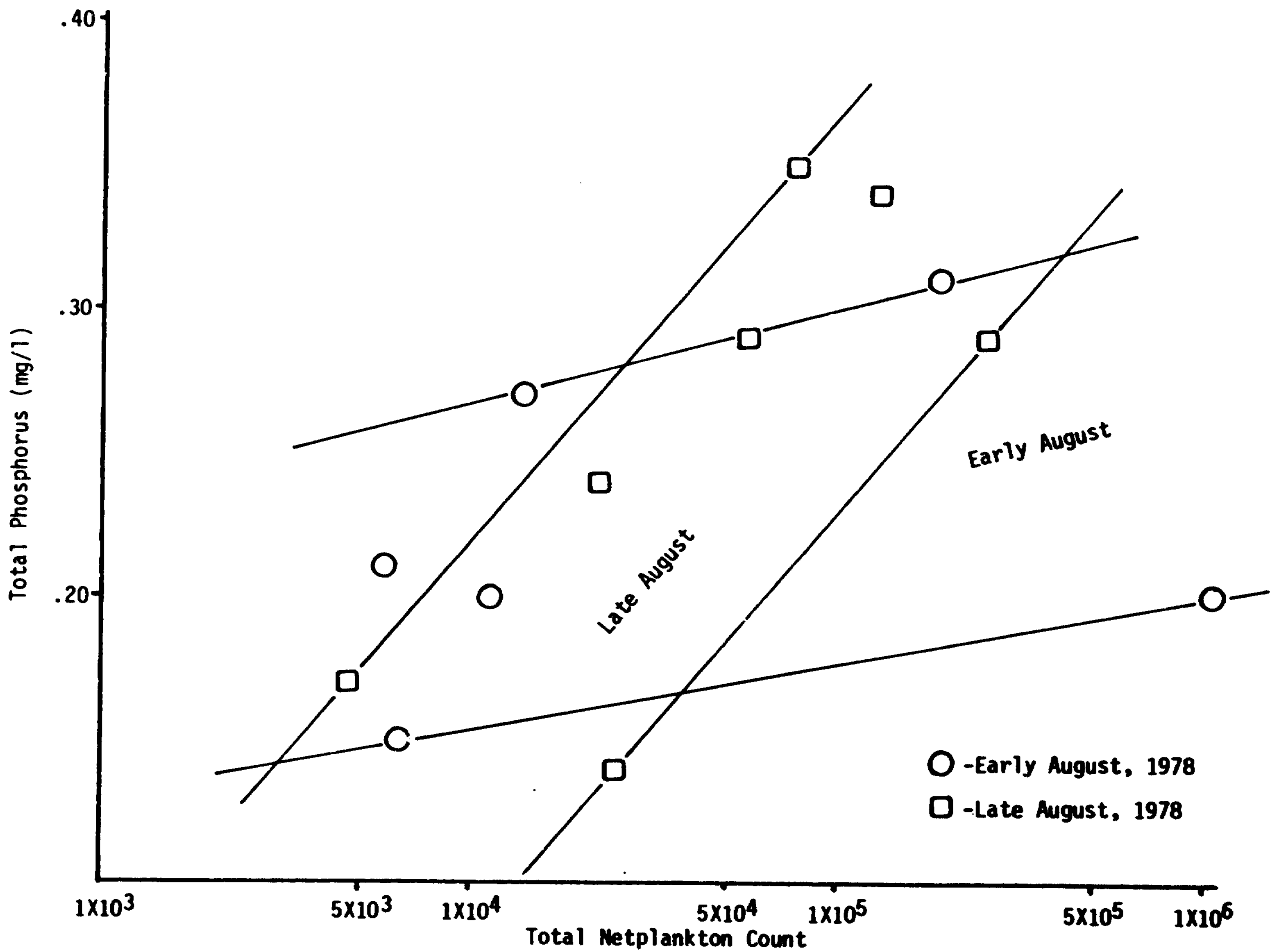

Figure 7. TOTAL PHOSPHORUS VS. NETPLANKTON

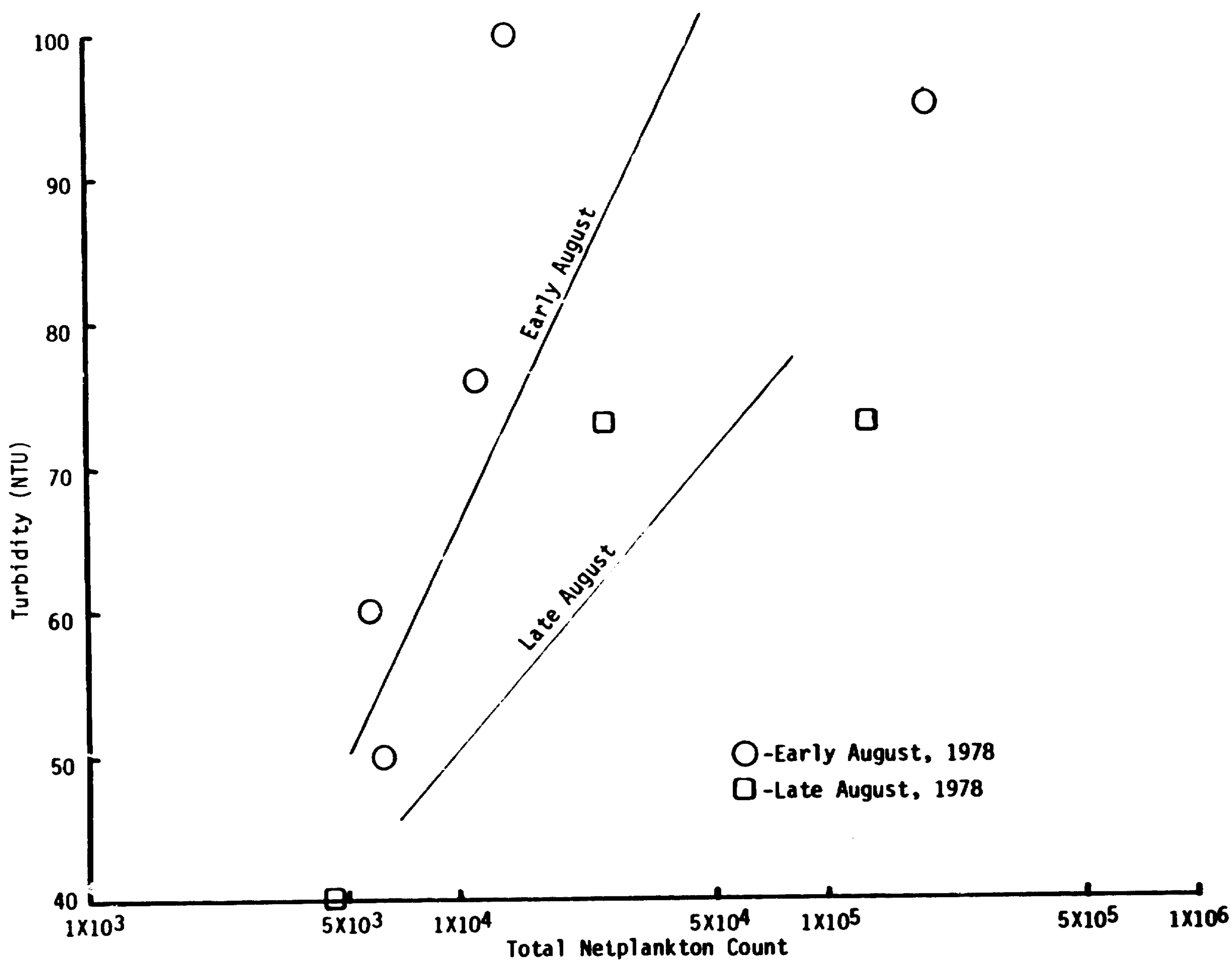

Figure 8. TURBIDITY VS. NETPLANKTON

as would be expected. These increases are again at different rates for the 2 dates. If the difference between these slopes are statistically significant, then they reflect a decrease with time as do the slopes in Figure 5. With this in mind, the question of what relationship exists between turbidity and HCMM surface temperature was raised. Figure 9 shows that there is very little if any change in temperature as turbidity increases and that turbidity varies significantly throughout the lake for both dates.

It has been well established that there is a definite relationship between turbidity and day visible reflectively readings. The HCMM DV data will be plotted with turbidity data in order to evaluate that relationship. Turbidity associated with sediment should correlate well with the day visible data as should turbidity associated with algae blooms. However, the sediment turbidity should not correlate well with surface temperature. Plots such as in Figures 5, 8, & 9 along with re lectivity data will help distinquish between these types of turbidity.

Temperature and Groundwater

HCMM infrared data for the agricultural area around Utah Lake have also been preliminarily examined and compared to a limited amount of depth to groundwater data. In the Canadian Aeronautics and Space Institute's Remote Sensing of Soil Moisture and Groundwater Workshop Proceedings (1976), statements were made to the effect that shallow aquifers can affect soil surface temperatures. In Figure 10 some groundwater data is plotted against HCMM temperatures. Groundwater data was obtained from county percolation tests performed during the study period. There appears to be a general trend of lower temperatures near the surface. Additional data, especially for the shallow groundwater/ lower temperature areas, is needed. This is presently being acquired and analyzed.

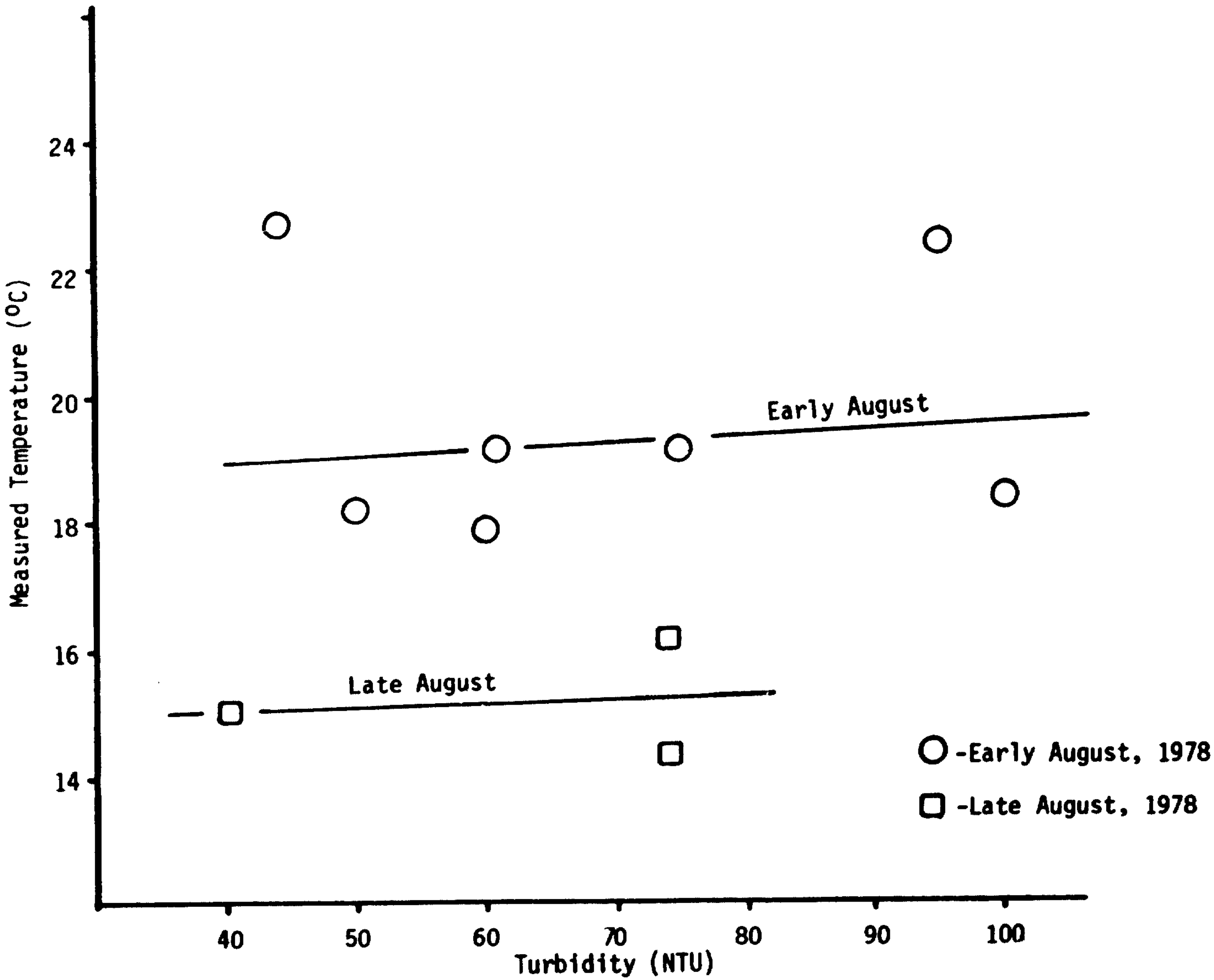

Figure 9. HCMM TEMPERATURE VS. TURBIDITY

ORIGINAL PAGE IS
OF POOR QUALITY

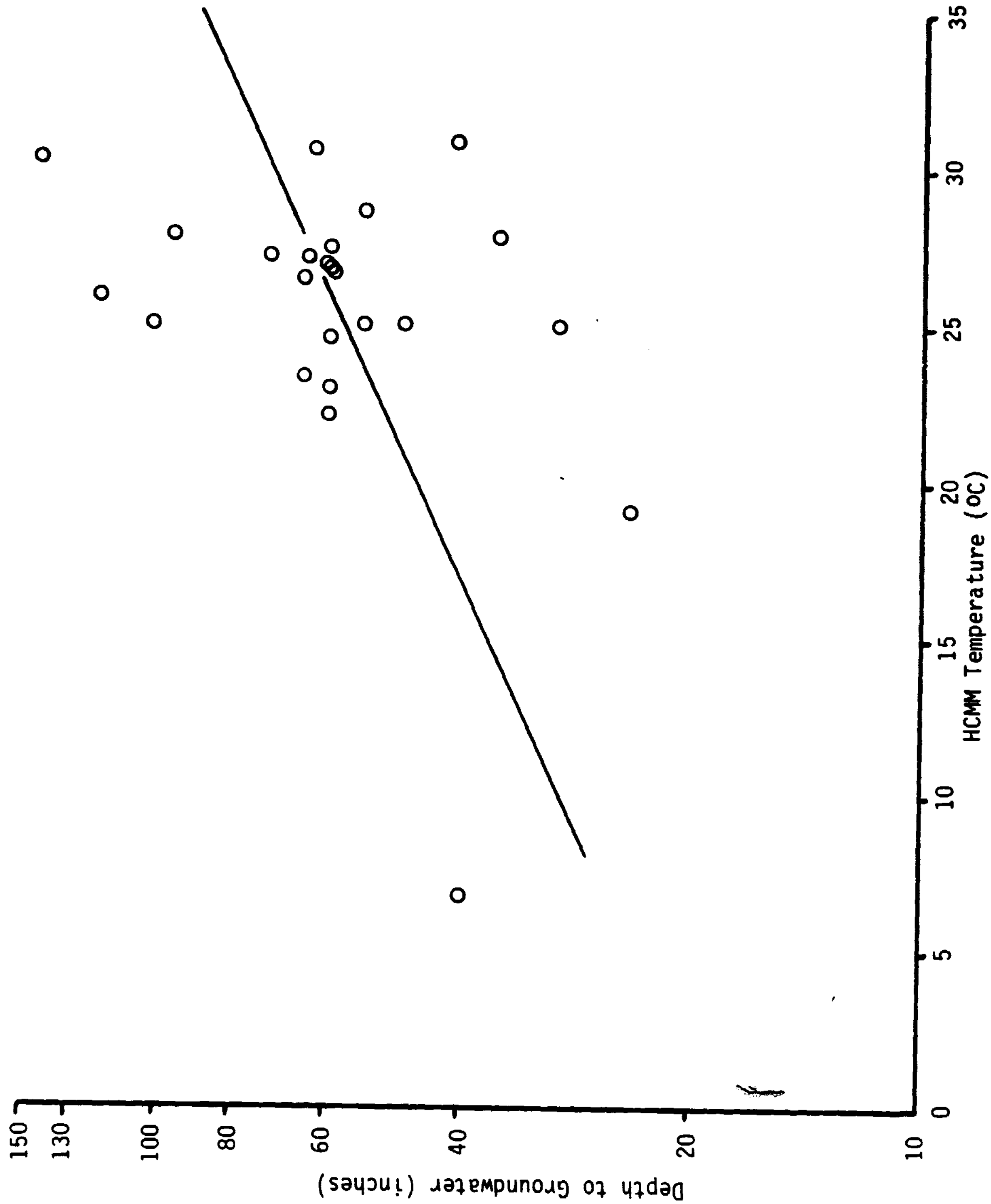

Figure 10. DEPTH TO GROUNDWATER VS. HCMM TEMPERATURE

REFERENCES

Barnes, W. L. and John C. Price, "Calibration of a Satellite Infrared Radiometer", Applied Optics, Vol. 19, No. 13, 1 July 1980.

Canadian Aeronautics and Space Institute, "Remote Sensing of Soil Moisture and Groundwater", Workshop Proceedings, Nov. 8-10, 1976.